Applicant	:	William A. Sirignano
Appl. No.	:	10/766,132
Examiner	:	Sarah Sachie Clark
Docket No.	:	703538.4032

Remarks

In the office action, the Examiner withdrew claims 24-25 as being directed to a non-elected invention, objected to the drawings, rejected claims 1-12 under 35 USC 112, second paragraph, as being indefinite, rejected claims 1-12, 15-17 and 19-21 under 35 USC 103 as unpatentable over prior art of record, and rejected claims 1-12, 15-17, and 19-21 under the judicially created doctrine of obviousness-type double patenting ov claims 1-16 of USPN 6,877,978. Applicants disagree with the Examiner's basis for these rejections and in view of the foregoing amendments and following remarks, Applicants request reconsideration and withdrawal of the Examiner's rejections. Applicant respectfully submits that Claims 1-12, 15-17, and 19-21, as amended, are in condition for allowance.

Eleclection/Restriction

Applicants have cancelled claims 24-25. Applicants submit, however, that claim 15 is generic and that when allowed, Applicants plan to resubmit claims 24-25 for allowance in this case.

Drawings

Applicants have submitted herewith formal drawings and submit that such submission is in compliance with 37 CFR 1.121(d).

Claim Rejections – 35 USC 112

The examiner has rejected claims 1-12 as indefinite due to the phrase "a means for forming a ... liquid film on the chamber's interior surface ." Applicants submit that the "means" includes among other things "a plurality of liquid fuel injectors, each coupled to one of the plurality of orifices and oriented tangentially to a wall of the chamber and orthogonally to the

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major flow direction within the chamber" as claimed in claim 8 and/or a swirl generator as claimed in claim 10. Accordingly, Applicants submit that claims 1-12 are not indefinite and meet the requirements for patentability under 35 USC 112, second paragraph.

Claim Rejections – 35 USC 103

The examiner has again rejected claims 1-12, 15-17 and 19-21 under 35 USC 103. The Examiner rejected claims 1-4, 6, 7, 10-12, 15-16 and 19-21 under 35 USC 103 as unpatentable over Schirmer '118, claims 1-5, 7, 10-11, 15-16 and 19-21 as unpatentable over Meurer, claims 8-9 as unpatentable over Meurer in view of Schirmer '672, and claims 15 and 17 unpatentable over Rao. In doing so, Applicants respectfully submit that the Examiner has failed to correctly apply the second prong of *Gardner*. According to the Federal Circuit in *Gardner*, "[1] where the only difference between the prior art and the claims was a recitation of relative dimension of claimed device and [2] a device having the claimed dimension ***would not perform differently***" then the claimed device is not patentably distinct. *Gardner v. TEC Sys.*, 725 F.2d 1338, 1347, 220 USPQ 777 (Fed. Cir. 1984), *cert.* denied, 469 U.S. 830, 225 USPQ 232 (1984). In considering the 2nd prong, what is relevant is the operation of the prior art device at the claimed size limitation, not whether the prior art device operates the same or similar outside of the claimed size limitation. Here, not only would a device having the claimed dimension perform differently, the devices of the cited art would fail. As a result, the claimed size limitations patentably distinguish the claimed invention, notwithstanding other differences, over the prior art because the size limitations make a significant difference in the operation of the prior art systems. *Id.*.

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In addition to not meeting the size limitation, the cited referenced clearly do not teach, describe or suggest forming and maintaining a stable liquid film to reduce the combustion heat loss to the chamber wall to avoid quenching as claimed in amended claims 1 and 15, nor do they teach, describe or suggest a means to do so. Moreover, Schirmer '188 actually teaches away from the claimed size limitation by teaching adding air for quenching. For obviousness, the whole reference must be considered.

Addressing the size limitation in greater detail, claim 1 is not obvious over Schirmer '118 or Meurer as each of these cited references fails to teach or suggest an operable miniature combustor wherein at least one dimension of the combustor chamber is sub-centimeter and wherein the combustor includes a means for forming a film of liquid on the chamber's inner surface. Moreover, one of ordinary skill in the art would not turn to these references for a teaching relevant to the claimed invention as the operation of the apparatus of these references would tend to fail at the claimed dimensional limitations. See Declaration of Carlos Fernandez-Pello (hereinafter "Pello" Decl.) at ¶¶ 5 and 7-12 and Declaration of Paul Ronney (hereinafter "Ronney Decl.) at ¶¶ 5 and 7-12)[Submitted with Applicants response filed 20 May 2005].

In the present case, the prior art systems such as those disclosed in Schirmer '118 and Meurer, would not function at the sub-centimeter dimensions of the present invention. Id. The dimensional aspects of miniature combustion chambers create different phenomena which prevent the principles of larger combustion chamber systems from operating in smaller, miniaturized combustion chambers. Pello Decl. at ¶ 5; Ronney Decl. at ¶ 5.

At the claimed dimensions, i.e., sub-centimeter lateral dimension, which are comparable to known quenching distances, the surface-to-volume ratio for the combustion chamber is so

large that a flame is typically not sustainable within the chamber due to the large heat transfer losses to the chamber walls. To overcome this wall quenching phenomenon, the applicants teach and claim injecting a liquid, fuel or inert, as a film that covers the entire or substantially the entire area of the chamber walls. With a liquid film applied to and maintained on the chamber walls, the heat transferred from hot combustion gases is captured by the liquid film protecting the chamber walls and, thus, preventing substantial heat loss to the chamber walls. When the liquid is a fuel, the heat transferred from the hot combustion gases will serve to aid in vaporization of the liquid fuel so it is burned before it exits the chamber. Pello Decl. at ¶ 6; Ronney Decl. at ¶ 6.

Current technology for larger systems does not rely on liquid fuel filming on the chamber walls (though some fuel is intentionally vaporized from intake manifolds in IC engines as part of the charge preparation). Instead, to keep the ratio of liquid surface area to liquid volume large enough to sustain high fuel vaporization rates, the fuel is typically injected as a spray. The intention is to vaporize the liquid as a spray before very much liquid deposits on the walls or solid surfaces of the chamber. If the fuel were filmed in these larger engines or combustors, without fuel atomization, the surface area of the liquid would not be large enough to sustain the needed vaporization rate for combustion. Because the S/V ratio of any wall film will grow as the volume of the combustor decreases, the liquid fuel film in combustors in the sub-centimeter size range tends to provide a liquid surface area for vaporization comparable to a vaporizing spray. Furthermore, the liquid fuel film protects against heat losses at the wall and, thus, quenching, that a vaporizing spray does not. Simply scaling existing combustion systems down to the lateral dimensions taught and claimed would result in combustion failure due to quenching. Pello Decl. at ¶ 7; Ronney Decl. at ¶ 7.

Accordingly, it would not have been obvious to one of ordinary skill in the art at the time of the applicant's invention to have scaled the apparatuses of Schirmer '118 and Meurer to applicant's claimed dimensions. In combustors, dimensions cannot be simply scaled in proportion because the physics become tremendously important when the combustor dimensions are scaled, especially when scaled downward to the claimed dimensions Thus, the teachings of these references would not lead one of ordinary skill in the art to the miniature combustion chamber and process taught and claimed by the applicants. Pello Decl. at ¶ 8; Ronney Decl. at ¶ 8.

Turning specifically to Schirmer '118, it is clear that author has not considered the scaling effects resulting in quenching as it indicates that there is substantial heat transfer to the chamber wall at column 3, lines 30—32 by noting that the chamber must have high mechanical strength and be resistant to elevated temperatures. Further , Schirmer '118 prescribes the addition of air to quench the flame in the chamber thereby implying the non-existence or lack thereof of any wall-quenching effect. Moreover, by teaching the adding of air for the purpose of quenching, Schirmer effectively teaches away from the claimed invention. Pello Decl. at ¶ 9; Ronney Decl. at ¶ 9.

It is also clear that Schirmer '118 is directed to larger-scale combustors than those taught and claimed by the applicants as it relates only to the physics that operate in large scale combustors. For instance, at column 2, lines 18—20 Schirmer '118 indicates the presence of a "highly turbulent shear interface of the fuel and the air." It is common textbook knowledge that turbulence occurs when the Reynolds number, which increases in direct proportion to the length scale of the flow passage, is large, or the onset of turbulence in a fluid occurs only when the

product of the velocity and the representative length dimension exceed a threshold. Another indication that Schirmer '118 is directed to larger-scale combustors occurs at column 2, Lines 22—25, where velocities up to 250 feet per second are deemed allowable. In a chamber dimension of ten centimeters or less, this **allows about a millisecond or less for combustion** to occur which tends to be too short a time to accomplish the vaporization, mixing of fuel vapor and oxidizer, and chemical oxidation processes which in totality and in sequence form the combustion process. Pello Decl. at ¶ 10; Ronney Decl. at ¶ 10.

The statement at column 3, Lines 1-14 of Schirmer '118 regarding "self-regulation of the wall temperature" is simply not correct because the so-called fuel layer would break-up into droplets and vaporize. Thus, self-regulation occurs as applicants indicate by maintaining a stable liquid film on the wall, not as Schirmer suggests at column 2, lines 11—22:

> Broadly speaking, my combustion apparatus permits the introduction of fuel uniformly onto the entire inner surface of the primary combustion chamber through a porous liner spaced from the inner wall of the chamber, and the introduction of air in the form of a vortex into the primary combustion chamber so that the flow of air spirals or swirls coaxially through the primary combustion chamber. Combustion apparently is effected at the highly turbulent shear interface of the fuel and the air. The shear interface, and therefore the combustion occurs near the surface of the porous wall and in the mixing zone.

It is common text book knowledge that at the prescribed flow rates of Schirmer '118, the shear forces would be such that the layer of fuel on the chamber walls will become unstable and break-up into droplets for vaporization and, thus, heat protection of chamber walls is lost. Pello Decl. at ¶ 11; Ronney Decl. at ¶ 11.

Turning to Meurer, it also does not address the issues of heat loss and quenching associated with smaller dimensions. Specifically, Meurer does not prescribe that the combustion chamber wall should be fully or substantially covered by a stable liquid layer to reduce heat

losses. Moreover, Meurer teaches cooling the combustion wall with air thus indicating an acceptance of heat loss to the walls. Scaling of Meurer would result in combustion failure due to quenching as a result. Pello Decl. at ¶ 12; Ronney Decl. at ¶ 12.

As for Schirmer '672, it addresses gaseous fuel and atomized liquid fuel only. As discussed above, simply scaling of Schirmer's device to the dimensions of applicants, and nothing more, would result in combustion failure due to quenching. Pello Decl. at ¶ 13; Ronney Decl. at ¶ 13. Thus, its combination with Meurer adds nothing to Meurer. Accordingly, claims 1-12 meet the requirements for patentability under 35 U.S.C. 103 in view of Schirmer '118, Meurer, and Schirmer '672.

Independent Claim 15 recites a combustion process that includes "forming and maintaining a liquid film over substantially an entire interior surface of the chamber" wherein the combustion chamber comprises "a lateral dimension transverse to a major flow direction within the chamber that is sub-centimeter." The Examiner rejected Claims 15 and 17 under 35 USC 103 as being unpatentable over Rao (US 4604988).

Rao considers a situation in his vortex device where the liquid is not the fuel or a chemical reactant. Only heat transfer and no mass transfer occur between the liquid and the core gas flow. Rao prescribes a method and apparatus for contacting a flow of heated gas with a flow of liquid to form a mist. The class of devices discussed in Rao certainly does not include combustors. The use of a flame to produce an exhaust gas for injection into the chamber does not make the chamber a combustor chamber. Moreover, would not teach or suggest forming and maintaining a liquid film on the interior surface of a sub-centimeter combustion chamber to affect combustion therein. Pello Decl. at ¶ 14; Ronney Decl. at ¶ 14.

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In addition to the nonobviousness arguments presented above, the pending claims are not obvious because there is a long felt, but unsatisfied need to produce highly efficient miniature combustion chambers. Pello Decl. at ¶ 15; Ronney Decl. at ¶ 15. Highly efficient miniature combustion systems could be used in the growing number of devices that are of reduced size. These devices require an energy source with a power density which is greater than current rechargeable batteries. The present invention discloses such a system and tends to reduce the possibility of quenching of the flame. Other miniature combustion chambers have not solved the problems created by the high surface-to-volume ratios which result in high heat transfer losses and flame quenching. As disclosed, the present invention solves the quenching problem to create a highly efficient miniature combustion chamber. Further, the present invention allows the use of typical hydrocarbon fuels. Other miniature combustion chambers require substitution of hydrocarbon fuels for quench resistant fuels such as hydrogen gas.

Accordingly, because the prior art fails to teach, suggest, or disclose all of the elements of the claimed invention and because there is a long felt, but unsatisfied need to produce highly efficient miniature combustors, Applicant respectfully submits that Claims 1-12, 15-17, and 19-21.

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Conclusion

Applicant submits that the claims are in condition for allowance. Should the Examiner have any questions regarding this Amendment, he is invited to call the undersigned attorney at (949) 567-6700.

Respectfully submitted,
ORRICK, HERRINGTON & SUTCLIFFE LLP

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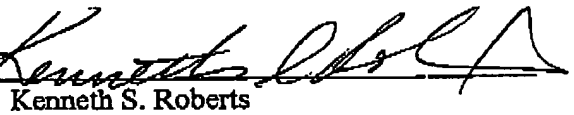
By: 
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